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ABSTRACT

A study examined variables that affect the acquisition of automaticity of verbal skills. Among the variables examined were practice, novelty or familiarity of a word or word category, the speed and efficiency with which persons acquire automaticity, reaction time, and number of tasks performed concurrently. Subjects, 30 sixth and seventh grade students at the university school at the University of Wyoming, were randomly assigned to order of treatment. Each student participated in three 30-minute sessions. Session one included instructions, two 20-task decoding practice trials, instructions, and two 30-task decoding trials with reaction times recorded. Sessions two and three began with review instructions followed by three 30-task trials. Students were allowed ten minutes of game time with a computer game disk following the second and third sessions to add attractiveness to the otherwise monotonous decoding activity. The first task was a visual task, the second an aural task, and the third task was a dual-task involving both visual and aural modes. Single task reaction times were briefer than under dual task conditions, reaction time was reduced from trials one through eight and subjects responded to familiar words more rapidly than to unfamiliar words. Reading level, number of tasks, familiarity of stimuli and practice accounted for approximately 42% of the variance in reaction time for the aural task. (HTH)

EFFECTS OF FAMILIARITY, READING LEVEL AND PRACTICE ON DUAL-TASK VERBAL PROCESSING

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PROBLEM

LaBerge and Samuels (1974) raised a question regarding training methods which facilitate the acquisition of automaticity of verbal skills. An enhanced understanding of the variables that affect the development of automaticity would be an appropriate precedent to the development of training methods. The purpose of this investigation was to examine variables that affect the acquisition of automaticity. More specifically it has addressed automaticity in decoding words, both written and spoken. The educational implications of this research have been directed toward reading but the design and theoretical basis for this study is extracted from research in information processing.

Initially, an intuitive approach can be applied to determining the most cogent variables affecting automaticity as a general process. Referring to an example of driving an automobile, it is observed that beginning drivers move their heads frequently. They look down to make sure their foot hits the brake pedal or the gas. They look at their hands to insure that the correct gear is selected and quickly back to the road to see if they must make mid-course corrections. Each look implies a focus of attention and when that occurs some other tasks are left unattended. The unattended tasks do not work as smoothly as the attended tasks. A ride with a beginning driver can be a jerky if not frightening experience. But with

practice, a smoothness settles on the scene as eyes remain on the road while a hand moves deftly to the gear shift and a foot glides automatically to its place on the clutch pedal. The first variable identified was practice. Practice has as significant a role in the acquisition of reading skills as it does driving skills.

Drivers sometimes daydream while driving. They would be more likely to do so while driving on a stretch of highway they had driven numerous times than on an unfamiliar road. Knowing through experience the length of curves, gradient of hills, and the like, reduces the amount of stimuli that must be attended to and provides freedom to attend to other matters. Our experience is that greater effort to attend must be exerted when reading material is highly familiar. It is difficult to listen to music and at the same time vocalize a word from print that one has never before or at least infrequently seen. The second variable involved the novelty of a stimulus or how familiar a reader was likely to be with a word or category of words.

The third variable was drawn from a class of variables that cluster as answers to the question: Do some persons acquire automaticity in some tasks more rapidly or efficiently than others? The individual difference variable singled out for this study was reading level.

The independent variables in this study include: level of practice in a word decoding task, the familiarity level of each

word decoded, and the reading level of each subject in the experiment.

The choice of a dependent variable required a measure that would quantify an event that cannot be directly observed. Pachella (1974, p. 43) stated, "The only property of mental events that can be studied directly, in the intact organism, while events are taking place, is their duration." Time is a measure that is directly meaningful since its determination is not arbitrarily set. What was sought then, was the time required to decode each word and respond correctly. The dependent variable was therefore reaction time (RT). It can be argued that a consistent reduction in RT represents the establishment of automaticity or at least the proficiency necessary for such an occurance.

Because automaticity becomes an important factor only under conditions requiring the simultaneous performance of two or more activities, it was important to consider one other variable. This variable exists because of the experimental design and was actually a measure of the design rather than a variable that impacts on the development of automaticity. This design variable can be labeled number of tasks. The RT of a decoding task performed singly was compared with the RT of an identical coding task performed concurrently with another decoding task. Increased RT under conditions of dual task performance implied stress to attentional capacity.

The research questions regarding these variables were:

1. Does dual task performance exceed attentional capacity limits as evidenced by dual-task RT being of significantly longer duration than single-task RT?

2. Is the RT for familiar words of shorter duration than that of unfamiliar words?

3. Is there a significant reduction in RT over trials?

4. Is the RT of poor readers of longer duration than the RT of good readers?

5. Which of the three independent variables shows the strongest effect?

VARIABLES

The following variables comprised the independent variables of this study.

1. Familiarity has two levels, familiar and unfamiliar. Noble (1953) found familiarity of a word, defined as a function of its frequency of occurrence, to be positively related to meaning. This suggests that the variable of meaningfulness increases in strength in an organism as a measure of the frequency of contact with the word. The same researcher (Noble, 1954) found the relationship between familiarity and frequency was such that it would suggest the initial stimulations had a greater effect than stimulation occuring following a number of previous exposures. Becker (1976) used word frequency as drawn from a standardized word frequency scale as an independent variable. Reaction time differences were larger for low-frequency words than for high-frequency

words. The stimulus words used in this study were selected from familiarity scales developed by Bowen (1969). The words were divided in the scales by frequency and by conceptual category. Each conceptual category had thirty-five words. Tables were formed for frequency occurrences of .22-1, <1-4, and 5-100 words per million (w.p.m.). For this study, familiar words were defined as the last five words in a category from a table with a 5-100 w.p.m. frequency of occurrence. Unfamiliar words were the first five words in a category from a table with a 1-4 w.p.m. frequency of occurrence. Familiarity was treated as a within subject variable.

2. Reading level was treated as a continuous variable. it was defined as the total reading battery score on Form E or Form F of the Stanford Achievement Test. These two forms constitute Level Two of the achievement test ;and are administered to fifth and sixth grade students. Reading level is the only between subjects variable in this experiment.

3. One unit of practice was defined as the completion of one trial consisting of thirty decoding tasks. The students participated in ten trials. The first two trials were presented as practice trials and reaction times were not recorded. The subsequent eight trials were the criterion trials. Practice was a within subject variable. Shiffrin and Schneider (1977) argued for the crucial nature of training leading to the development of automaticity.

The single dependent variable in this study was reaction time. Reaction time is the interval between the onset of the stimulus presentation and the initiation of the subjects' response. The stimulus presentation in the visual task was a single word on the computer monitor with a beep sounding from the console concurrent with the appearance of the word. The onset of the aural stimulus was a word presented through earphones by means of a speech synthesizer. Subject response for the visual task was to say either "job" or "name". Subject response in the aural task was to move the joystick to the left or to the right. Therefore, visual task reaction time was the interval from the beep to initiation of the words "job" or "name", and aural task reaction time was the interval between the beginning of the synthesized word and the joystick signal.

The design variable was number of tasks. The two levels for the variable are single and dual. Single-task is defined as the presentation of either the aural task or the visual task by itself. ; under dual-task conditions, the visual task and the aural task appear simultaneously. Number of tasks was; treated as a within subject variable.

HYPOTHESES

H1: There is no linear relationship between reading level and reaction time on a set of verbal decoding tasks.

H2: There is no difference between mean reaction times for single-task and dual-task performance on a set of verbal

decoding tasks.

H3: There is no difference between mean reaction times for familiar words and unfamiliar words on a set of verbal decoding tasks.

H4: There is no difference between trial mean reaction times for trials one through eight of a set of verbal decoding tasks.

H5: There is no interaction effect of familiarity with practice on reaction time.

All null hypotheses were tested using the criterion for statistical significance of 0.05. The single depender variable in this study was reaction time. Reaction time is the interval between the onset of the stimulus presentation and the initiation of the subjects' response. The stimulus presentation in the visual task was a single word on the computer monitor with a beep sounding from the console concurrent with the appearance of the word. The onset of the aural stimulus was a word presented through earphones by means of a speech synthesizer. Subject response for the visual task was to say either "job" or "name". Subject response in the aural task was to move the joystick to the left or to the right. Therefore, visual task reaction time was the interval from the beep to initiation of the words "job" or "name", and aural task reaction time was the interval between the beginning of the synthesized word and the joystick signal.

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METHODOLOGY

The subjects for this study were 30 sixth and seventh grade students at the university school at the University of Wyoming for whom reading scores on the Stanford Achievement Test, Forms E and F were available. Students were randomly

assigned to order of treatment. The treatment was the same for all participants so order of treatment was determined by random number assignment.

Each student participated in three thirty minute sessions. Each session was held on a separate day with no more than two days between any two sessions. Each session was scheduled at a different time of day. Students were dismissed from class and instructed to report to the assigned room. All instructions regarding the purpose and procedures of the experiment were presented in the assigned room.

Session one included instructions, two twenty task decoding practice trials, instructions and two thirty task decoding trials with reaction times recorded. Following the second criterion trial the student was introduced to a computer game disk and informed that he or she would be allowed ten minutes of game time following the next two sessions. Session two and three began with review instructions followed by three thirty task trials. Computer game time concluded each session. The purpose of the game time was to add attractiveness to the activity. The decoding trial could become monotonous.

Following a sufficient time for the student to respond the correct response or responses appeared on the screen. A new task was randomly generated and the student responded again and the process continued through thirty tasks. The computer recorded the time interval for each aural task. Reporting the correct responses to the student is based on findings by

LaBerge and Samuels (1974) that feedback is essential to the growth of automaticity.

The first task was the visual task. A word such as "CHARLES" appeared on the screen for 750 milliseconds which is equivalent to the duration of the longest aural stimulus. The student decided if "CHARLES" belonged to category "NAME" or category "JOB". The student responded by saying "NAME". "CHARLES IS A NAME" then appeared on the screen. The reaction time was calculated for that response. "CHARLES" was a familiar stimulus. An example of an unfamiliar stimulus from the name category would be "GLADSTONE".

Task two was the aural task. In an example of this task, the student heard the word "GAZELLE" through the headphones. The student's decision would be between the category "CLOTHING" and the category "ANIMAL". The student's correct response would be to move the joystick to the left. "GAZELLE IS AN ANIMAL" then appeared on the screen. "GAZELLE" was an unfamiliar stimulus. "HUMAN" would have been a familiar stimulus.

Task number three was the dual-task. The student heard "COCKLE" through the earphones and saw "GENDARME" on the monitor at the same time. "GENDARME" would disappear from the screen at about the same time that "COCKLE" was completely pronounced. The student selected from "JOB" or "NAME" for "GENDARME" and "ANIMAL" or "CLOTHING" for "COCKLE" and responded appropriately. The correct answers appeared and

would have read "COCKLE IS AN ANIMAL", "GENDARME IS A JOB" for this example.

Instructions were intended to maximize performance and minimize distractions.

1. The visual task was described and students instructed to respond loudly "job" or "name". They were instructed to watch for the correct answer.

2. The aural task was described and students instructed to move the joystick left for "animal" and right for "clothing".

3. Following the practice trials, task number three was described. Students were instructed to do both tasks as fast as possible.

4. Instructions between trials for all three sessions were regarding checking for accuracy, keeping eyes on screen, keeping hand on joystick, and working as fast as possible.

The program prpvided a printout of each trial with the following information:

1. The task number of each of the 30 stimuli.

2. The category of each single-task and the categories of each dual-task presentation.

3. The stimulus i.e. FLIES, PAJAMAS, etc.

4. Whether the presentation was single or dual task.

5. The react'on time of each aural task.

6. Whether each aural task response was correct or incorrect.

7. A blank in which to record the accuracy of each visual task response.

8. A blank in which to record the reaction time for each visual task.

9. Subject identification code.

The reading level was determined by Grade Equivalent reading scores on the Stanford Achievement Test, Forms E and F.

Computer hardware used in this experiment included and Apple II+ with a clock, speech digitizer, headphones and a joystick. The software for this study was a program written especially for this study utilizing the Super Talker digital recording program.

RESULTS

The dependent variable utilized in this study was the reaction time for correct responses. The means and standard deviations for RT of the within-subjects variables, which were number of tasks, familiarity, and practice, displayed predicted trends in RT differences. Single task RT weere more brief than under dual task conditions, RT was reduced from trials one through eight and subjects responded to familiar words more rapidly than to unfamiliar words. The significance of those trends was revealed by the analysis of covariance procedures.

The reading level of each subject was the only

between-subjects variable and was treated as a covariate in the analysis of covariance. The relationship of this variable was significant, $F(1,28) = 16.2$, $p<.0005$, for the aural task.

The second hypothesis of this study addressed the single-dual task paradigm. An analysis of covariance of the RT with reading level of the covariate performed. The difference between the dual and single task conditions was significant, $F(1,29) = 37.09$, $p<.0001$ in the aural task.

Hypothesis number three was concerned with the time differences in responding to familiar and unfamiliar words. The differences between those conditions were significant, $F(1,29) = 61.92$, $p< .0001$ in the aural task.

Analysis of covariance for the practice effect yielded, $F(7,203) = 16.86$, $p<.0001$ in the aural task.

The analysis of covariance produced two significant interactions. Within the aural decoding task a significant $F(7,203) = 2.21$, $p<.05$, interaction occurred between practice, familiarity and number of tasks.

To determine the magnitude of the relationship between each independent variable and reaction time a hierarchical regression was performed. This procedure constituted a reanalysis of all variables to dtermine the relative contribution of each variable to the total variability in reaction time. The order of entry was: (1) the covariate reading level, (2) the set of main effects, and (3) the set of interactions.

The regression analysis was performed on the aural decoding task data. Reading level was entered first and found to be significant, $F(1,238) = 63.66$, $p<.001$. The squared simple correlation was 121 or 21% of the RT variance was accounted for by reading level. The block of independent variables was significant, $F(3,235) = 29.74$, $p<.001$. The squared semi-partial correlation was .22. This is interpreted as 22% of the RT variance being explained by the set of variables indentified in this experiment, over and above that accounted for by the covariate.

The independent variables were then tested separately. The difference in the single-dual conditions was significant, $F(1,237) = 32.08$, $p<.001$, and accounted for 9% of the RT variance. Familiarity was significant, $F(1,237 = 26.81$, $p<.001$. The difference between familiar and unfamiliar explained 7% of the RT variance. The practice effect was also significant, $F(1,237) = 21.72$, $p<.001$, in the aural task. The squared semi-partial correlation was .05, even though this variable was also weakened by the necessity of combining the trials. The aural task set of interactions was non-significant, with $F(8,231) = .34$, $p>.05$.

One additional set of computations produced the squared partial correlations for the within-subjects variables. This correlation removes variance that is due to the covariate reading level from both the within-subjects variable and RT. The partial refers to the fact that reading level has been

partialed from the variables. These effect sizes are exclusive from rather than over and above reading level variance.

A test of the homogeneity of regression assumption to justify an analysis of covariance was performed. This was a test for interactions of the covariate with the independent variables. The result of the test on the aural data was significant, $F(3,228) = 3.298$, $p<.05$, which suggests some evidence of a violation of the homogeneity of regression assumption. Reading level interacted with one or more of the main independent variables.

A sphericity test revealed a violation of the assumption of compound symmetry for the practice variable in the aural task ($p<.01$). The Greenhouse-Geisser probabilities (Winer, 1971) were used as a conservative estimate of significance.

DISCUSSION

Reading level, number of tasks, familiarity of stimuli and practice accounted for approximately 42% of the variance in reaction time for the aural task. To have isolated variables that account for such a large proportion of variance was an important result of this study. The findings of these experiments should encourage strong consideration of these variables in certain training strategies, especially when a high degree of verbal proficiency is an objective.

The significant effect of reading level points to some underlying, individual differences associated with verbal

learning. The decoding task in both the aural and visual experiments was a very precise behavior that has been described as a sub-task associated with reading. The analysis of the data pointed to a significant parallel between a specific behavior and a general measure. This connection adds credence to the declared association of verbal decoding with reading.

The operational definition for familiarity was firmly associated with frequency of occurrence for a stimulus. The frequency of occurrence measured was a global frequency for the general population, rather than a given individual. It was a measure of population usage. After ten trials, the effects of this variable were still evident, distinct from practice which was essentially a repetition of occurrence. These results should encourage the consideration of strategies in teaching which enhance familiarity. Excercises which increase knowledge of individual vocabulary words as well as the reading of literature requiring an expanding vocabulary should be utilized.

Practice is another variable that can be manipulated to affect performance in verbal learning. The relationship appears to be direct; increase practice for a corresponding increase in performance. The limitations of such a formula from this study would be that there is yet to be the establishment of the number of trials for which such a direct relationship would exist.

Rather than testing a current theory regarding automatic

information processing, the focus of this study was to examine variables that to this point have not been included in dual-task research. Reading level, familiarity, and practice effects on dual-task performance constituted a unique set of research questions. In addition to testing the effects of the selected variables it was also a goal of this investigation, which included both pilot and experimental portions, to identify highly similar mental operations that could be performed simultaneously. A third puprpose of this study was to test the independent and design variables on an age group that had received minimal attention in previous dual-task research. Impaired performance of sixth and seventh grade students under dual-task conditions of aural verbal decoding was established to be significant. Enhanced performance under conditions of word familiarity and practice was also verified.

The results of the present study lead to several possible topics for further research. With regard to reading level as an individual difference measure, are there other individual difference variables that would impact on the same performance tasks? What would be the effect of further practice trials? At what point would performance begin to level off? What learning activities with unfamiliar words would diminish the familiarity effect? The present study has identified specific variables that impact on verbal learning but has not investigated the conditions and limitations of those variables.

Reading while attending to extraneous stimuli and

daydreaming while driving were cited previously as examples of misuses of automatic information processing. This study has examined several variables and their relationship to performing two tasks simultaneously. Misuses of the ability to perform concurrent tasks will undoubtedly continue, even in classrooms. To those who care about facilitating verbal learning in their students, perhaps this research will contribute to an understanding of the appropriate use of automaticity in those same classrooms.

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